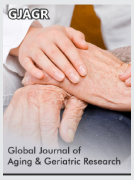

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# Effects Of Cognitive Training Through Exergames on Cognition in Active Community-Dwelling Older-Adults

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## Abstract

This study aimed to verify the effects of training with exergames on the cognitive functions of active older adults in the community. The training group (TG) performed training with exergames twice a week for three months. The control group (CG) did not perform any activity during the period. Cognitive performance was assessed by the Mini Mental State Examination (MMSE) and its components: immediate memory, temporal orientation, spatial orientation, attention, recall and language. Possible differences between scores were tested using Student's t and the frequency of improvement between the initial and final assessment between groups was tested using Chi-square. The study had 100 participants, 62 in the TG and 38 in the CG. The two groups were similar on sex ($p=0.981$, 87% women), age ($p=0.241$, mean age of $70.5 \pm 7.79$ years), education ($p=0.276$, with a mean of $10.1 \pm 4.575$ years of formal education) and baseline cognitive performance: the CG scored $26.6 \pm 2.66$ and the TG $26.9 \pm 2.52$ in the MMSE ($p=0.510$). At second assessment, there was a significant improvement in the total MMSE score in TG, ending with $28.8 \pm 1.38$ points ($p<0.001$), while CG remained at $26.6 \pm 2.53$. The TG showed a significantly higher frequency of improvement than the CG in immediate memory (43.6% versus 15.8, $p<0.001$), temporal orientation (33.9% versus 15.8, $p<0.001$) and spatial orientation (29 % versus 7.9, $p=0.004$). Although not significant, the GT also showed improvements in calculation, recall and language compared to the CG. We concluded that exergames were effective in improving cognitive performance even in healthy older adults.

## Introduction

Cognitive functions are important for the functional autonomy of the elderly. Several studies have focused on finding better strategies to prevent decline and rehabilitate these functions. Cognitive training is an intervention designed to mitigate the decline in cognition [1]. Among the types of cognitive training there is cognitive training through electronic games controlled by body movement, called active video games or exergames. These games have specific rules and objectives to be achieved, providing feedback to players during practice and have proven to be an alternative for the prevention and rehabilitation of cognitive decline in older adults. This type of game allows for greater individualization of training, senso ry feedback on the proposed activity and the integration between motor and cognitive skills [2].

With the advancement of technology, it is possible to develop highly motivational and well-designed games, immersing players in the virtual world, contributing to stimulating participation in games and facilitating cognitive and brain functioning [3,4]. Another advantage of exergames is that they can offer experience for the task requirements of daily life based on the simultaneous training of physical and cognitive components [5]. Some research with reviews and meta-analyses indicate that older adults can benefit from cognitive training. Although the beneficial effect of exergames has been observed in older adults with mild cognitive impairment [6,7], there are still few studies that have demonstrated their possible benefit in active older adults in the community. Therefore, the objective of this work was to verify the effects of cognitive training with exergames on the cognition of active older adults in the community.

## Methods

This is a controlled and randomized clinical trial (Training Group - GT and Control Group - CG). Data collection was carried out at the Institute of Geriatrics and Gerontology of the Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre - Brazil, from August 28 to December 23, 2019. Participants were invited to the research through the distribution of informative pamphlets in groups of different physical and recreational activities in the Sports Park and on the central PUCRS Campus. All volunteers who were willing to participate in the project were included. Participants with attendance lower than 75% in the proposed activities and those who did not complete the second assessment were excluded, in this case mainly among those in the control group.

The instrument used for cognitive assessment was the Mini Mental State Examination (MMSE) developed by Folstein et al. (1975). The MMSE is composed of two parts: one that covers orientation, memory and attention and another that addresses specific skills such as naming and understanding [8]. The questions present in the instrument are related to the ability to: follow television programs, difficulty understanding in noise, difficulty understanding in silence, difficulty finding the right word, difficulty expressing thoughts, forgetting what they should do, forgetting of family names, temporal orientation, spatial orientation, immediate memory, delayed memory, executive memory, and language.

Initially, neuropsychological assessments were carried out. After the assessments were carried out, the elderly were divided into two groups: control group (CG) and training group. (GT). The GT had an initial participation of 68 older adults and the GC started with 67 older adults. The GT ended the study with 62 participants and the CG ended with 38 participants. The TG performed cognitive training for three months, while the CG did not undergo training. At the end of this period, both underwent a new neuropsychological assessment to investigate the impacts of cognitive training. The total number of training sessions carried out was 617; Among the participants who completed the training, the number was 611 with an average of 9.9 training sessions per participant, with a minimum of 4 training sessions and a maximum of 12.5 training sessions. In total, 235 neuropsychological assessments were carried out (135 initial and 100 final). The third evaluation provided for by the project was carried out with only 11 participants and had to be interrupted in accordance with a Brazilian State Decree of March 19, 2020, related to the Covid-19 pandemic. Due to the low number of participants, these data were not analyzed. Six participants dropped out of the GT, three of whom migrated to the control group and underwent the second assessment. The dropouts in the GC were greater, forming a total of 29 people. 38 GC participants and 62 participants completed the second assessment.

The MMSE was carried out in both groups of older adults, before and after the GT underwent three months of cognitive training. The results of the initial and final assessments were compared between groups and tested by unpaired Student's t using the EPI Info 7.41 program. The research was registered by the Research Ethics Committee of the Pontifical Catholic University of Rio Grande do Sul (PUCRS) under number CAAE 02854712.1.0000.5336 and approved by opinion 3.285.048. All participants read and signed the Informed Consent Form (TCLE) before starting the training.

## Results

Initially, 135 older adults were evaluated, 68 being allocated to the GT and 67 to the CG. Six participants from the TG did not complete the minimum number of 8 training sessions and 29 from the CG did not appear for the second evaluation. In this way, 100 participants completed the research, 87 women and 13 men, 38 participated in the GC and 62 participated in the GT. The two groups presented similar data regarding gender, age group, education, self-perceived health and multimorbidity. The average age of the sample was 70±7.79 years, with no significant difference between the groups. In the sample, 87% of individuals described themselves as white, with an average of 10±4.55 years of study. Regarding marital status, 39% were married and 30% widowed. Participants were asked about their self-perception of health, with 47% reporting good health and 31% fair health. Regarding engagement in social activities and receiving friends and family, the average total frequency was 1.9 and 1.4 times a week, respectively (Table 1).

**Table 1:** Sociodemographic, clinical and lifestyle characteristics among the participants.

| | Control | Training | Total | p |
|---|---|---|---|---|
| **Age (Years)** | 69.4±8.34 | 71.3±7.41 | 70.5±7.79 | 0.241 |
| **Gender** | | | | |
| **Females** | 33 (86.8%) | 54 (87.1%) | 87 (87.0%) | 0.971 |
| **Males** | 5 (13.2%) | 8 (12.9%) | 13 (13.0%) | |
| **Color/race** | | | | |
| **White** | 30 (79.0%) | 57 (91.9%) | 87 (87.0%) | 0.179 |
| **Indigenous** | 1 (2.6%) | 0 (0%) | 1 (1.0%) | |
| **Brown** | 3 (7.9%) | 1 (1.6%) | 4 (4.0%) | |

| | | | | |
|---|---|---|---|---|
| **Back** | 4 (10.5%) | 4 (6.5%) | 8 (8.0%) | |
| **Marital status** | | | | |
| **Marriage** | 16 (42.1%) | 23 (37.1%) | 39 (39.0%) | 0.618 |
| **Divorced** | 7 (18.4%) | 14 (22.6%) | 21 (21.0%) | |
| **Single** | 3 (7.9%) | 7 (11.3%) | 10 (10.0%) | |
| **Widow(er)** | 12 (31.6%) | 18 (29.0%) | 30 (30.0%) | |
| **Years of education** | 9.5±4.38 | 10.5±4.65 | 10.1±4.55 | 0.276 |
| **Self-perception of health** | | | | |
| **Excellent** | 7 (18.4%) | 13 (21%) | 20 (20.0%) | 0.94 |
| **Good** | 19 (50.0%) | 28 (45.2%) | 47 (47.0%) | |
| **Regular** | 11 (29.0%) | 20 (32.3%) | 31 (31.0%) | |
| **Bad** | 1 (2.6%) | 1 (1.6%) | 2 (2.0%) | |
| **Days of Physical activities (weekly)** | 1.9±1.53 | 2.2±1.59 | 2.1±1.57 | 0.348 |
| **Days of Social activities (weekly)** | 1.7±1.49 | 2.1±1.59 | 1.9±1.56 | 0.25 |
| **Number of visitors received (weekly)** | 1.5±1.56 | 1.3±1.13 | 1.4±1.31 | 0.793 |
| **TOTAL** | 38 (38.0%) | 62 (62.0%) | 100 (100%) | |

Table 2 shows the initial and final MMSE averages for the two groups studied. Cognitive performance assessed by the MMSE was initially similar between the groups (p=0.510). In the final evaluation, the training group showed an important and statistically significant improvement compared to the control group (p<0.001). When comparing individual performance, 76% of participants who completed the training improved in the test, while the control group saw improvement in 40% of participants, this association being significant (Table 2).

**Table 2:** Average performance on the cognitive test (MMSE), initial and after the intervention or follow-up (final) for both groups researched.

| | Control | Training | Total | p |
|---|---|---|---|---|
| **MMSE initial score** | 26.6±2.66 | 26.9±2.52 | 26.8±2.57 | 0.51 |
| **MMSE final score** | 26.6±2.53 | 28.8±1.38 | 28±2.18 | <0.001 |
| **MMSE change** | | | | |
| **improved** | 15 (39.5%) | 47 (75.8%) | 62 (62.0%) | <0.001 |
| **remained** | 10 (26.3%) | 13 (21.0%) | 23 (23.0%) | |
| **worst** | 13 (34.2%) | 2 (3.2%) | 15 (15.0%) | |
| **TOTAL** | 38 (38.0%) | 62 (62.0%) | 100 (100%) | |

Table 3 shows the results of the evaluation of these components. The results of the assessment of immediate memory, temporal orientation and spatial orientation showed a statistically significant difference between the groups. Regarding the results of the attention assessment, this difference was not significant (p=0.134). In the results of the recall and language components, there was also no significant difference between the control and training groups. It can be observed that individuals who performed training with exergames improved or maintained their scores in all MMSE components, as well as no worsening of them, compared to those who participated in the control group (Table 3).

**Table 3:** Distribution of changes in the performance of the components of the Mini-Mental State Examination, after intervention and follow-up for the researched groups.

| MMSE change | Control | Training | Total | p |
|---|---|---|---|---|
| **Immediate Memory** | | | | <0,001 |
| No improvement | 32 (84,21%) | 35 (56,45%) | 67 (67%) | |
| Improved | 6 (15,79%) | 27 (43,55%) | 33 (33%) | |
| **Temporal orientation** | | | | 0,048 |

| | | | | |
|---|---|---|---|---|
| No improvement | 32 (84,21%) | 41 (66,13%) | 73 (73%) | |
| Improved | 6 (15,79%) | 21 (33,87%) | 27 (27%) | |
| **Spatial orientation** | | | | <0,012 |
| No improvement | 35 (92,11%) | 44 (70,97%) | 79 (79%) | |
| Improved | 3 (7,89%) | 18 (29,03%) | 21 (21%) | |
| **Attention** | | | | 0,134 |
| No improvement | 26 (68,42%) | 33 (53,23%) | 59 (59%) | |
| Improved | 12 (31,58%) | 29 (46,77%) | 41 (41%) | |
| **Evocation** | | | | 0,431 |
| No improvement | 38 (100%) | 61 (98,39%) | 99 (99%) | |
| Improved | 0 (0%) | 1 (1,61%) | 1 (1%) | |
| **Language** | | | | 0,168 |
| No improvement | 35 (92,11%) | 51 (82,26%) | 86 (86%) | |
| Improved | 3 (7,89%) | 11 (17,74%) | 14 (14%) | |

## Discussion

Regarding sociodemographic data, the two groups studied were homogeneous, most older adults in both groups classified their health as "good", the marital status that had the highest prevalence in both groups was "married". Both groups had a high average level of education, corresponding to high school and the majority with higher education. This educational level is higher than the average level of education for Brazilian older adults. In the analysis of the 2013 National Health Survey of the Brazilian Institute of Geography and Statistics (IBGE), [9] it was observed that 60% of the older adults evaluated had up to 4 years of education, with 23% being illiterate. This data shows that the older adults studied are active and socially integrated older adults, with the possibility of maintaining and stimulating their cognitive functions.

Regarding gender, most participants were female, a finding that is recurrent in studies with older adults. The life expectancy of elderly Brazilians is higher for women and, according to the IBGE, the projection for Brazilian life expectancy is currently 72 years for men and 79 years for women. As for the Brazilian aging index, considering the population aged ≥ 60 years, the number reached 80.03 in 2022, that is, there are 80 older adults for every 100 children aged 0 to 14 [10]. After three months of training, it was possible to verify a statistically significant difference between the CG and GT in the GT's total score in the MMSE and in the subtest's immediate memory, temporal orientation and spatial orientation, showing the improvement of the training group after the intervention. In a review published by [11], the authors sought to understand the effects of using exergames on the brain and cognition of healthy older adults and concluded that exergames can improve cognitive processes. According to Torre & Temprado, these results suggest that movement has benefits, which is not surprising given the widely demonstrated effects of physical activity to prevent age-related declines in functional capabilities in healthy older adults. Regarding the improvement of individual cognitive domains after training with exergames, studies do not show consistency.

In the study by Stojan and Rehage (2019), the authors researched the cognitive benefits and neurophysiological correlates of training with exergames in healthy older adults. Through the analysis of 15 articles, it was concluded that training with exergames is equally or more effective than other physical interventions on cognitive functions in healthy older adults, however, these findings did not show consistency in relation to the improvement in the cognitive domain studied [12] researched the effects of using exergames on the cognitive performance of older adults and when analyzing the cognitive domain, the authors observed positive effects in several domains (attention, visuospatial skills, cognitive flexibility, inhibitory control). Furthermore, the authors identified beneficial effects in the use of exergames for both older adults with cognitive impairment and healthy older adults.

In studies carried out with older adults who had motor and cognitive losses due to the diagnosis of stroke, there was also a significant improvement with virtual reality technologies, which include exergames, tablets, smartphones, computers. In their research Belle, [13] states that "virtual reality has the potential to apply neurorehabilitation concepts to stroke patients, such as intensive, repetitive and task-oriented training" (p. 3). The authors state that the main explanation for the improvement in motor and cognitive skills is related to "cortical reorganization, which occurs during the performance of induced movements, resulting in the mechanism of neuroplasticity" (p. 4). Following the authors' reasoning, the increase in performance in people with neurological losses is deeply linked to visual information and extrinsic feedback provided using virtual reality. In the authors' study, improvements were seen in the participants' physical performance, in addition to improvements in visuospatial memory and visual attention. There is still little research on the use of exergames and virtual reality to date. However, most findings corroborate that digital games improve the motor and cognitive performance of healthy and unhealthy older adults, as they stimulate movements in a playful way, also contributing to increased self-esteem and social inclusion in the most diverse environments.

## Conclusion

The present work sought to evaluate the cognitive benefit of exergames training in older adults participating in activities at a Community University in the city of Porto Alegre, RS. The exercise program was very well accepted by participants given the low number of dropouts. The main difficulty in the work was keeping the participants in the control group, which significantly reduced the sample size in the last evaluation. A third evaluation (washout) was planned, three months after the end of the training period. Unfortunately, the third assessment culminated at the beginning of the COVID-19 Pandemic and could not be carried out. However, the findings were robust enough for us to conclude that cognitive training with exergames was effective in improving cognition in healthy older adults. Although many studies focus on research on older adults with mild or moderate cognitive impairment, we observed that older adults, even without these health problems, can benefit from cognitive exercise. Public policies to promote health among older adults must therefore include cognitive exercises among other well-established policies such as food security and encouragement of physical activity.

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None.

## Conflict of Interest

No Conflict of Interest.

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